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SKIN NECROSIS OCCURRING ON POTATO TUBERS AFFECTED BY BLACK DOT (COLLETOTRICHUM ATRAMENTARIUM) AFTER EXPOSURE TO LOW TEMPERATURES

DOOR

J. C. MOOI

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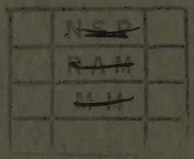

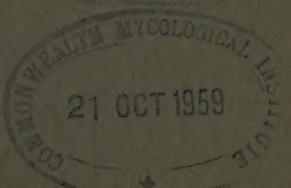

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A Skin necrosis occurring on potato tubers affected by Black dot *(Colletotrichum atramentarium)* after exposure to low temperatures

(Preliminary communication)

door

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A SKIN NECROSIS OCCURRING ON POTATO TUBERS AFFECTED BY BLACK DOT *(COLLETOTRICHUM ATRAMENTARIUM)* AFTER EXPOSURE TO LOW TEMPERATURES

(PRELIMINARY COMMUNICATION[1])

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Summary, Zusammenfassung, Résumé, p. 65

In 1955 WENZL described a skin necrosis of potato tubers the symptoms of which were as follows. Patches of necrotic tissue occurred on the diseased tubers. The patches were often superficial, but in some instances the necrotic tissue penetrated rather more deeply into the flesh of the tuber. The microsclerotia of *Colletotrichum atramentarium* (BERK. & BR.) TAUB. were most in evidence on the necrotic tissue.

The disease occurs during storage and is especially found after severe winters (WENZL, 1955, 1956). In WENZL's opinion the disease is primarily due to temperatures below 0°C. If tubers are exposed to such a low temperature necrotic lesions may arise on the skin and the necrosis is able to penetrate more or less deeply into the flesh of the tuber. *C. atramentarium* increases the severity of the lesions but is not a primary cause of the disease.

BRAUN (1955) has also written on the subject of skin necrosis. He termed the disease "Schalennekrose". In many cases he isolated *C. atramentarium* from the necrotic patches. BRAUN did not succeed in obtaining symptoms of skin necrosis by artificial inoculation of potato tubers with this fungus. He held the view that *C. atramentarium* is only a secondary invader. He also did not think the disease is caused by frost, since in VOSZ's extensive investigation (1956) into the damage caused to the potato tuber at low temperatures there are never any symptoms resembling skin necrosis. A deep-set necrotic spot, the only symptom caused by low temperature which somewhat resembles the patches of this skin necrosis, can easily be distinguished from these patches.

Despite this, BRAUN has suggested in a recent article that low temperature may be a causative factor of skin necrosis (BRAUN, 1958). He writes: It would seem that skin necrosis is caused by disturbances in the cell equilibrium of which the effect is overlooked under normal storage conditions, but may increase considerably with a rapid and sudden drop in temperature and possibly also under other conditions. In BRAUN's opinion it is too early to say anything about the cause of the disturbances in the equilibrium.

[1] Received for publication 12th February 1959.

Skin necrosis of potato tubers also occurs in the Netherlands. The author has tried to ascertain the cause of the disease. In view of the results of Vosz's investigation it seemed doubtful whether, as stated by WENZL, low temperature was the main cause of skin necrosis symptoms. The author thought, however, that skin necrosis might possibly be caused in tubers exposed to low temperature if they were affected by black dot (*C. atramentarium*) before this treatment. In 1957 an experiment was started in order to examine the correctness of this theory.

Plants of the variety Eigenheimer were grown in a glasshouse in pots containing sterilized soil. They were divided into three batches. Each batch consisted of fifteen plants. In one batch the seed tubers were disinfected before planting (batch A) by applying a seed potato disinfectant based on an organo-mercury compound. In another batch the seed tubers were also disinfected, but the soil was artificially inoculated with *C. atramentarium* (batch B). A third batch consisted of non-disinfected seed tubers (batch C). Planting was carried out in June. By the beginning of October all haulms were dead. Shortly afterwards the tubers were harvested and examined. The tubers of batch A were free of spots, but a great many were observed in batch B. These spots exhibited the characteristics of black dot, although many lacked the microsclerotia of *C. atramentarium*. Isolations were made from some of these spots and always yielded *C. atramentarium*. Black dot occurred on the tubers of batch C, but to a much less extent than on the tubers of batch B. The infection of the tubers of batch C apparently originated from the seed tuber.

Half of the tubers harvested were stored in an environment of high relative humidity (humid storage). They were placed in pots and covered with a little soil. The pots were wrapped in polyethylene sheets. The remaining tubers were stored in an environment with a relatively low humidity (dry storage). These were placed in open baskets. During the first month of storage the temperature was about 10° C and subsequently about 5°C until storage ended in May 1958.

In February 1958 of each batch a part of the tubers stored in pots, and a part of the tubers stored in open baskets were mixed up and put in a container. The tubers in these containers were covered with soil and exposed to a temperature of −1,1°C for a fortnight. After this treatment the tubers were stored at 3,5°C for three days. On the third day a number of tubers were examined. On the tubers of batch B, which had been stored under humid conditions since October, many dark brown necrotic lesions could be observed which did not occur on the tubers before they had been exposed to a temperature of −1,1°C.

Three days later all tubers exposed to a low temperature were examined. On the tubers of batch B, which had been stored under humid conditions, the said necrotic lesions were found in nearly every case. There were none to be found on the tubers of batch B, which had been stored dry, nor on the tubers of batch A and C, but as the tubers were rather dirty it was not possible to subject them to a careful examination. The tissue of the necrotic lesions was brown and moist and penetrated into the flesh of the tuber to a depth of some millimetres. Since the spots caused by black dot remained more superficial, the necrotic lesions could be clearly distinguished from them. After

the tubers had been examined they were all stored in the same way as before submission to the low temperature treatment.

In the beginning of May all tubers were washed. Some which had been exposed to a temperature of −1,1 °C were soft and watery through having been entirely or partly frozen and these tubers were removed. The greatest number of the tubers exposed to low temperature remained unfrozen. They were carefully examined and by this time the lesions referred to above were more deep-set and the necrotic tissue had become dry and grey. There was no enlargement of the lesions since they had been examined in February. Their size varied from some sq. millimetres to some sq. centimetres. The outline also varied greatly, sometimes being more or less circular and sometimes very irregular (FIG. 1). The lesions often occurred at the outline of a spot caused by *C. atramentarium*. In such cases they were of somewhat annular of partly annular shape (FIG. 1).

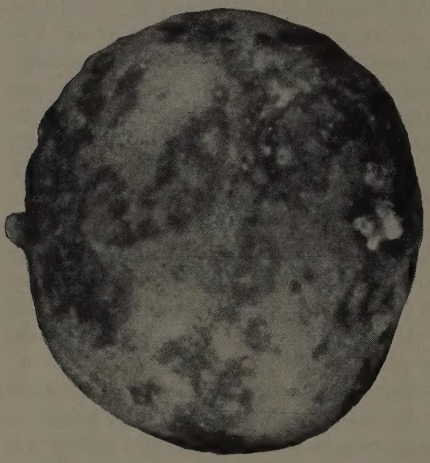

FIG. 1.
Skin necrosis induced experimentally on a potato tuber affected by black dot (*Colletotrichum atramentarium*) after exposure to a temperature of −1,1 °C for a fortnight

ABB. 1.
Schalennekrose künstlich erzeugt auf einer Kartoffelknolle, auf der Flecken durch Colletotrichum atramentarium-*Befall verursacht vorkamen und die während zwei Wochen einer Temperatur von −1,1 °C ausgesetzt wurde*

FIG. 1.
Nécrose péridermique artificiellement provoquée sur un tubercule de pomme de terre, atteint par Colletotrichum atramentarium, *et qui avait été exposé à une température de −1,1 °C pendant deux semaines*

Patches of the same circular shape can be seen on a tuber shown in FIG. 3 of BRAUN's article. On the whole the disease showed a striking resemblance to those deputed in Figures 1 to 4 of BRAUN's article and Figures 3 to 5 of WENZL's article (WENZL, 1955).

No necrotic lesions were observed on the tubers which had not been exposed to a temperature of −1,1 °C.

The incidence of black dot on tubers of the three batches stored in pots or in open baskets and not exposed to a temperature of −1,1 °C was established. The results are listed in TABLE 1. From investigations carried out earlier it was known that black dot does not spread during dry storage. Hence the figures in TABLE 1 which show the incidence of black dot in May on tubers stored in open baskets are also the figures for the incidence of black dot at the beginning of storage. So the percentage of black dot infection of the tubers of batch B, stored under dry conditions which in May 1958 was

30 %, was also 30 % in October 1957. The percentage of infection of tubers of the same batch stored in pots was 60 % in May, so that black dot increased during the storage under humid conditions. Only very little black dot was found on the tubers of batch A stored in pots. More black dot was found on the tubers of batch C stored in pots, but silver scurf occurred also, and it was not always possible to distinguish these two diseases. It may be assumed, however, that black dot also increased on the tubers of batch C during the storage under humid conditions, as was the case with the tubers of batch B, though the figures in TABLE 1 do not indicate such an increase.

TABLE 1. Incidence of black dot (*Colletotrichum atramentarium*) in tubers of batches A, B and C as found in May 1958 after storage under dry or humid conditions

Batch *Objekt* *Objet*	Storage *Lagerung* *Conservation*	Surface area of the tubers affected by black dot in % of total surface *% der gesamten Oberfläche der Knollen besetzt mit Flecken durch C. atramentarium verursacht* *% de la surface totale des tubercules couverts de taches provoquées par C. atramentarium*
A	dry – *trocken – sèche*	0
	humid – *feucht – humide*	1
B	dry – *trocken – sèche*	30
	humid – *feucht – humide*	60
C	dry – *trocken – sèche*	5–10[1]
	humid – *feucht – humide*	5–10[1]

[1] The % of affection could not be accurately determined as silver scurf also occurred on the tubers.
Der Prozentsatz der Oberfläche besetzt mit Flecken, konnte nicht genau festgestellt werden weil auf den Knollen auch Silberschorf vorkam.
Le pourcentage de la surface couverte de taches ne pouvait être fixé avec précision, du fait que les tubercules étaient également atteints par la gale argentée.

TABELLE 1. *Das Auftreten von Flecken durch* C. atramentarium-*Befall auf Kartoffelknollen der Objekte A, B und C, festgestellt im Mai 1958, nach einer Lagerung in trockener oder feuchter Umgebung*

TABLEAU 1. *L'apparition de taches provoquées par* C. atramentarium *sur des tubercules de pomme de terre des objets A, B et C constatée en mai 1958, après stockage dans une ambiance sèche ou humide*

Batch A. Seed tuber disinfected, soil not inoculated with *C. atramentarium*
B. „ „ „ „ inoculated with *C. atramentarium*
C. „ „ not „ „ not inoculated with *C. atramentarium*
Objekt A. Pflanzkartoffel desinfiziert, Boden nicht infiziert mit C. atramentarium
B. „ „ „ *infiziert mit C. atramentarium*
C. „ *nicht* „ „ *nicht infiziert mit C. atramentarium*
Objet A. Plants désinfectés, sol non infesté par C. atramentarium
B. „ „ „ *infecté par C. atramentarium*
C. „ *non* „ „ *non infesté par C. atramentarium*

TABLE 2 shows the incidence of necrotic lesions in May on tubers of the three batches, stored under humid as well as under dry conditions, and exposed to a temperature of −1,1 °C. If we compare the figures of TABLE 2 with those of TABLE 1 it must be concluded that there is a correlation between the percentage of tubers on which necrotic lesions occurred after exposure to low temperature and the percentage of black dot infection in tubers of the same batch and the same manner of storage, not being exposed to low temperature. For example: much black dot was found on the tubers of batch B stored under humid conditions and examined in May. When tubers of this batch, stored in the same manner, were exposed to a temperature of −1,1 °C necrotic lesions arose on all tubers. Only very little black dot was observed on tubers of batch A, stored under humid conditions and examined in May. No necrotic lesions appeared when tubers of this batch, stored in the same manner, were exposed to a temperature of −1,1 °C.

TABLE 2. Incidence of necrotic lesions on tubers of batches A, B and C as found in May 1958 after storage under dry or humid conditions. Tubers exposed to −1,1 °C in February 1958

Batch *Objekt* *Objet*	Storage *Lagerung* *Conservation*	% of tubers on which necrotic lesions occurred *% der Knollen, auf denen Schalennekrosen vorkamen* *% des tubercules présentant des lésions nécrotiques*	Number of necrotic lesions per tuber *Anzahl der Nekrosen pro Knolle* *Nombre des lésions nécrotiques par tubercule*	% of tubers on which "blind" eyes occurred *% der Knollen, auf denen abgestorbene Augen vorkamen* *% des tubercules présentant des yeux morts*
A[1]	dry–*trocken*–*sèche*	0	–	0
	humid–*feucht*–*humide*	0	–	0
B[1]	dry–*trocken*–*sèche*	22	low–*niedrig*–*bas*	0
	humid–*feucht*–*humide*	100	high–*hoch*–*grand*	45
C[1]	dry–*trocken*–*sèche*	7	low–*niedrig*–*bas*	0
	humid–*feucht*–*humide*	88	low–*niedrig*–*bas*	28

[1] See TABLE 1.
Siehe TABELLE 1.
Voir TABLEAU 1.

TABELLE 2. *Das Auftreten von Schalennekrosen auf Kartoffelknollen der Objekte A, B und C, festgestellt im Mai 1958, nach einer Lagerung in trockener oder feuchter Umgebung. Die Knollen sind im Februar 1958 einer Temperatur von −1,1 °C ausgesetzt worden*

TABLEAU 2. *L'apparition de nécrose péridermique sur des tubercules de pomme de terre des objets A, B et C constatée en mai 1958, après stockage dans une ambiance sèche ou humide. Les tubercules ont été exposés à une température de −1,1 °C en février 1958*

In order to explain the said correlation, it was assumed that the spots caused by black dot influenced the adjoining tissue in such a way as to render it more susceptible to frost damage. There are some fungus diseases in which it was possible to observe a similar effect of the diseased tissue on the surrounding healthy tissue. LANGNER (1936), studying larch canker (*Trichoscyphella willkommii* (HART.) NANNF) obtained evidence that the mycelium of *Tr. willkommii* produced toxins in the tissue of the canker affecting the adjoining tissue so as to increase its susceptibility to frost. MOOI (1948) inoculated branches cut from *Salix alba* L. with *Nectria galligena* BRES. He showed that the tissue of the bark surrounding the anthracnoses caused by *N. galligena* was more susceptible to frost damage than the remaining tissue of the bark.

If the above hypothesis is correct there must be a proportional correlation between the incidence of necrotic lesions and black dot on the tubers. A comparison of the figures in TABLE 2 with those in TABLE 1 shows that this correlation is, in fact, proportional if the comparison is made between the tubers of the three batches stored in the same manner. If the comparison is made between tubers stored in a different manner it is found that the correlation is not proportional. This is particularly true of batch B. When the tubers of this batch were stored in pots, 60 % of the total surface area of the tubers was covered with black dot, as against 30 % when the tubers were stored in open baskets. But when tubers of batch B stored in pots were exposed to a temperature of −1,1 °C necrotic lesions appeared on all of them, as against only on 20 % of the tubers stored in open baskets. Moreover, a large number of lesions occurred on every tuber stored in pots, whereas only a few lesions were observed on every tuber stored in open baskets.

The fact that the correlation is not proportional when the tubers are stored in a different manner may be explained as follows. During storage under humid conditions black dot spreads, so that the mycelium of *C. atramentarium* remains active in the spots caused by this fungus. During storage under dry conditions black dot does not spead, so that the mycelium is apparently in a state of rest. Mycelium which is in an active condition will produce more toxins than dormant mycelium. If fungal toxins are able to render the host tissue more susceptible to frost, the tissue in the neighbourhood of spots on tubers stored under humid conditions will be more susceptible to damage caused by low temperature than the tissue in the neighbourhood of spots on tubers stored under dry conditions. For this reason many more necrotic lesions occurred on tubers of batch B stored in pots than on those stored in open baskets after submission to the low temperature treatment.

Both WENZL (1955) and BRAUN state that the skin necrosis they described has a bad effect on the sprouting of the tubers. In the experiments described above it was also found that the sprouting of tubers with necrotic lesions was often less vigorous than in the case of tubers without these necrotic lesions. It was found that when the sprouting was less vigorous one or more eyes of the tuber failed to sprout. If several such "blind" eyes were cut through it was found that the tissue of the bud and some neighbouring tissue was brown and necrotic. "Blind" eyes were only found on tubers of

batches B and C which were stored in pots and exposed to a temperature of −1,1 °C (TABLE 2).

It must be concluded from the results of the experiment described above that potato tubers on which black dot occurs are more susceptible to damage caused by low temperature. As we have seen above, the lesions caused on the tubers under these conditions bore a striking resemblance to those of the skin necrosis described by WENZL or that described by BRAUN. Both authors and especially WENZL, mention the importance of low temperature in the arising of the disease. Both state that *C. atramentarium* is most in evidence in the necrotic tissue. It is, therefore, assumed that at least in many cases the tuber disease investigated by these two authors is caused in the same way as the necrotic lesions in the experiment described above, i.e. through the combined action of *C. atramentarium* and low temperature. If this is true, *C. atramentarium* is not a secondary invader as supposed by WENZL and BRAUN, but a primary cause of the disease.

For several years the author observed in the Netherlands the symptoms of the disease described by WENZL and BRAUN, especially in 1956 after a severe winter. It should be emphasized, however, that these symptoms do not always arise on tubers exposed to low temperature. In several cases similar symptoms were seen on tubers, stored in a building of which the temperature was recorded. During the entire storage period the temperature was always higher than 0 °C. The symptoms were found on tubers of several varieties. They were usually noticed in the spring of each year, but they were not often serious in extent. In many cases isolations were made from diseased tubers which had always been stored at a temperature higher than 0 °C. In nearly all cases they yielded *C. atramentarium*. This fungus probably causes symptoms resembling those described by WENZL and BRAUN in certain circumstances on tubers not exposed to a low temperature. The author has proved this to be the case with tubers of the variety Saskia (MOOI, 1956). On tubers of this variety grown on sandy soil and infected by *C. atramentarium*, the mycelium does not remain in the superficial layers of the tuber but attacks the deeper tissue. The resultant skin necrosis bore a striking resemblance to those described by WENZL and BRAUN. Saskia is more susceptible to these infections than other varieties, but it is very probable that such an infection also occurs on tubers of several of the other varieties.

It can, therefore, be assumed that the said symptoms of skin necrosis may be caused in two ways:

1. *C. atramentarium* causes superficial spots on the tuber. If tubers so infected are exposed to temperatures below 0 °C skin necrosis may arise.
2. Under certain conditions C. *atramentarium* actively affects the deeper tissue of the tuber.

In his article on the tuber disease of Saskia (MOOI, 1956) the author assumed that the skin necrosis described by WENZL and BRAUN might be caused in the second way. Since WENZL (1956) in his second article adduced a great deal of evidence on the importance of low temperature in the occurrence of the disease described by him, the author believes that after severe winters skin necrosis is in most cases caused in the first way.

A SKIN NECROSIS ON POTATO TUBERS AFFECTED BY BLACK DOT

During investigations into diseases of potato tubers the author found that the later the tubers are harvested the more black dot occurs on them. It was also found that black dot increases during storage in clamps. The earlier tubers are harvested and the drier the conditions during storage, the less will be the incidence of black dot. Moreover, if the tubers are stored under very dry conditions the mycelium of *C. atramentarium* in the spots caused by black dot will be less active and render the adjoining tissue of the tuber less susceptible to frost. Tubers harvested early and stored under such conditions will be less susceptible to skin necrosis caused by low temperature than tubers harvested late and stored under humid conditions.

The experiments are to be continued.

SUMMARY

A SKIN NECROSIS OCCURRING ON POTATO TUBERS AFFECTED BY BLACK DOT (*Colletotrichum atramentarium*) AFTER EXPOSURE TO LOW TEMPERATURES

WENZL (1955, 1956) described a surface affection of potato tubers which, in the opinion of this investigator, is primarily due to the effect on the tubers of temperatures below 0 °C. BRAUN (1955) also described the tuber infection to which he gave the name skin necrosis ("Schalennekrose"). According to BRAUN the cause of this disease is unknown, but he assumed that low temperatures were partly responsible for the occurrence of the tuber infection (BRAUN, 1958). Neither of these two investigators believe that *Colletotrichum atramentarium* (BERK. et BR.) TAUB., which is often encountered on the affected portions of the tuber, is the primary pathogenic agent.

During 1957 and 1958 an experiment was carried out in order to examine the possibility of inducing artificially the disease symptoms described by WENZL and BRAUN by exposing to a low temperature tubers affected by black dot.

Potato tubers on which black dot patches had been artificially induced were exposed to a temperature of –1,1 °C for a fortnight. A small number of tubers froze after this treatment, but most remained unfrozen. On the unfrozen tubers many necrotic lesions occurred after the cold treatment which were not present before the tubers had been exposed to low temperature (FIG. 1).

Tubers free from black dot were simultaneously exposed to a temperature of –1,1 °C with the infected tubers. No necrotic lesions occurred after the cold treatment on tubers free from patches caused by *C. atramentarium* (TABLES 1 and 2). The disease symptoms on the tubers on which necrotic lesions had been observed closely resembled the symptoms described by WENZL and BRAUN. From the result of this experiment it was concluded that the tuber disease described by the said two investigators may be due to the fact that tubers exhibiting patches caused by *C. atramentarium* are exposed to temperatures below 0 °C. If this conclusion is correct, *C. atramentarium* is a primary pathogenic agent, and not a secondary one as supposed by WENZL and BRAUN.

Apparently the tissue of the tuber is so affected by the presence of the patches caused by *C. atramentarium* that in the vicinity of these patches it is more susceptible to injury caused by temperatures below 0 °C. It is possible that toxins secreted by the fungus living in the patches are the cause of the greater degree of susceptibility to injury by low temperatures.

During the investigation some of the tubers affected by *C. atramentarium* were stored in a dry atmosphere and some in a humid atmosphere. Under the latter conditions black dot spread on the tubers, but this was not the case with tubers stored in a dry atmosphere. The tubers so stored were then exposed to the above-mentioned cold treatment, care being taken to ensure that during the treatment there was an equal degree of humidity for the tubers stored under varying conditions. After the treatment many more necrotic lesions occured on the tubers stored in a humid atmosphere (TABLES 1 and 2). The difference in the number of necrotic sions was far too great for it to be assumed to

be due to the fact that more black dot had occurred on the tubers stored under humid conditions before being exposed to a temperature of −1,1 °C. The far greater number of necrotic lesions in the tubers stored under humid conditions may be explained by assuming that the tuber tissue in the vicinity of spreading patches caused by *C. atramentarium* is more severely affected by toxins secreted by this fungus than is the tissue in the vicinity of non-spreading patches. In the latter case the mycelium is, in fact, much less active and will consequently secrete few if any toxins.

The writer found that tuber disease symptoms closely resembling those described by WENZL and BRAUN could also occur on tubers which during storage had been constantly exposed to a temperature exceeding 0 °C. In the writer's view there are two ways in which the said symptoms may occur:

1. *C. atramentarium* causes superficial patches on potato tubers. If tubers so infected are exposed to temperatures below 0 °C skin necrosis may occur.
2. Under certain conditions *C. atramentarium* actively affects the deeper tissue of the tuber.

The writer believes that when a great deal of skin necrosis occurs after a severe winter, this chiefly occurs in the first way.

Black dot does not occur to any great extent on tubers harvested early and stored in the dry. If such tubers are exposed to temperatures below 0 °C less skin necrosis will occur on them than on tubers exposed to the same low temperature but lifted late in the season and stored in a humid atmosphere.

The experiments are to be continued.

ZUSAMMENFASSUNG

SCHALENNEKROSEN, BEI NIEDRIGEN TEMPERATUREN ENTSTEHEND AUF KARTOFFELKNOLLEN MIT FLECKEN DURCH *Colletotrichum atramentarium*-BEFALL (VORLÄUFIGE MITTEILUNG)

WENZL (1955, 1956) beschrieb eine oberflächliche Krankheit der Kartoffelknolle, deren Ursache nach seiner Meinung in erster Linie auf Kälteschäden zurückzuführen ist. BRAUN (1955) nannte diese Krankheit "Schalennekrose". Die Ursache der Schalennekrose ist nach BRAUN unbekannt, aber es scheint möglich, dass niedrige Temperaturen dabei eine Rolle spielen (BRAUN, 1958). Beide Autoren glauben nicht, dass *Colletotrichum atramentarium* (BERK. et BR.) TAUB., der häufig zusammen mit dieser Krankheit auftritt, primär an der Ursache der Erkrankung beteiligt ist.

In den Jahren 1957–1958 wurde untersucht, inwiefern es möglich ist die von WENZL and BRAUN beschriebenen Krankheitssymptome auf Kartoffelknollen, auf denen durch *C. atramentarium*-Befall verursachte Flecken vorkamen und die einer niedrigen Temperatur ausgesetzt wurden, hervorzurufen.

Knollen, auf denen die genannten Flecken experimentell erzeugt worden waren, wurden während zwei Wochen bei einer Temperatur von −1,1 °C gelagert. Einige Knollen erfroren nach dieser Kältebehandlung, aber bei den meisten war dies nicht der Fall. Bei den letztgenannten Knollen traten jedoch zahlreiche oberflächliche nekrotische Stellen auf, die vor der Kältebehandlung auf den Knollen fehlten (ABB. 1).

Knollen ohne durch *C. atramentarium*-Befall verursachte Flecken wurden gleichzeitig der genannten niedrigen Temperatur ausgesetzt. Auf diesen Knollen traten nach der Kältebehandlung keine Nekrosen auf (TABELLEN 1 und 2). Die Krankheitssymptome der Knollen mit den genannten nekrotischen Stellen waren den durch WENZL und BRAUN beschriebenen Symptomen vollkommen gleich. Aus diesem Versuch geht hervor, dass die durch diese beiden Autoren untersuchte Krankheit durch Zusammenwirkung zweier Faktoren entstehen kann: Bildung von Flecken auf den Knollen durch *C. atramentarium* und Lagerung dieser Knollen bei Temperaturen unter 0 °C. Sofern diese Feststellung sich als richtig erweist, ist *C. atramentarium* ein primär an der Ursache der Krankheit beteiligter Pilz und nicht nur sekundär wirksam, wie BRAUN und WENZL glauben.

Das Gewebe der Knolle wird offenbar durch die Bildung der Flecken infolge *C. atramentarium*-

Befalls derart beeinflusst, dass es in der Nähe dieser Flecken für Schädigung durch Frost empfindlicher wird. Es ist möglich, dass durch den in den Flecken lebenden Pilz ausgeschiedene Toxine Ursache der erhöhten Frostempfindlichkeit des an die Flecken grenzenden Gewebes sind.
Bei der Untersuchung wurden die Knollen, auf denen durch *C. atramentarium*-Befall verursachte Flecken vorkamen, teils trocken, teils bei hoher relativer Luftfeuchtigkeit gelagert, bevor sie der niedrigen Temperatur ausgesetzt wurden. In der feuchten Umgebung dehnten sich die Flecken aus, aber bei trocken aufbewahrten Knollen war dies nicht der Fall. Bei Kältebehandlung entstanden viel mehr Nekrosen auf den feucht als auf den trocken gelagerten Knollen. Zwar kamen auf den erstgenannten Knollen mehr Flecken vor, und deshalb wäre auf diesen Knollen nach der Kältebehandlung auch eine grössere Anzahl Nekrosen zu erwarten. Der Unterschied in der Auswirkung dieser Behandlung bei den verschieden gelagerten Knollen war aber viel zu gross, als dass er auf diese Weise erklärt werden könnte. Eine Deutung wäre vielleicht denkbar wenn man folgendes voraussetzt: Das Gewebe in der Knolle in der Nähe von sich ausdehnenden Flecken im Zusammenhang mit *C. atramentarium*-Befall, wird stärker durch von diesem Pilze ausgeschiedene Toxine beeinflusst werden, und deshalb empfindlicher für Frost sein, als das Gewebe in der Nähe von sich nicht ausdehnenden Flecken. Im letztern Falle ist das Myzel ja viel weniger aktiv und wird nur wenig oder gar keine Toxine ausscheiden.
Der Verfasser hat beobachtet, dass Krankheitserscheinungen, die genau den von WENZL und BRAUN beschriebenen Symptomen entsprachen, auch auf Knollen entstehen können, die während der Lagerung immer bei einer höheren Temperatur als 0 °C aufbewahrt waren. Er glaubt deshalb, dass diese Symptome auf zwei Arten entstehen können:

1. *C. atramentarium* erzeugt Flecken auf Kartoffelknollen. Wenn diese Knollen einer niedrigen Temperatur ausgesetzt werden, kann die Schalennekrose entstehen.
2. *C. atramentarium* dringt unter Umständen aktiv in das tiefere Gewebe der Knolle ein.

Der Verfasser glaubt dass, falls nach einem strengen Winter häufig Schalennekrose auftritt, diese Nekrose hauptsächlich auf die erste Weise entsteht.
Auf Knollen, die früh geerntet und trocken gelagert werden, kommen nicht viel Flecken durch *C. atramentarium*-Befall vor. Solche Knollen werden für Schalennekrose, die durch niedrige Temperaturen verursacht wird, weniger empfindlich sein als Knollen, die spät geerntet und feucht gelagert werden.
Die Untersuchungen werden fortgesetzt.

RESUME

NECROSE PERIDERMIQUE APPARAISSANT A DES TEMPERATURES BASSES SUR DES TUBERCULES DE POMMES DE TERRE ATTEINTS DE DARTROSE OU *Colletotrichum atramentarium* (COMMUNICATION PROVISOIRE)

WENZL (1955, 1956) a décrit une maladie péridermique du tubercule de pomme de terre, due – à son avis – en premier lieu aux dégâts causés par le froid. BRAUN (1955) appelait cette maladie nécrose péridermique ("Schalennekrose"). La cause est inconnue selon BRAUN, mais il est bien possible que les températures basses y soient pour quelque chose (BRAUN, 1958). Les deux auteurs ne croient pas que *Colletotrichum atramentarium* (BERK. et BR.) TAUB., qui apparaît souvent en même temps que cette maladie en soit la cause primaire.
En 1957–1958 on a examiné à quel point il était possible de provoquer les symptômes morbides, comme décrits par WENZL et BRAUN, sur des tubercules de pommes de terre atteints par *C. atramentarium* et exposés à des températures basses. Des tubercules sur lesquels avaient été provoquées lesdites taches par voie expérimentale furent stockés à une température de –1,1 °C pendant deux semaines. Certains furent tués par le froid, cela n'était pourtant pas le cas de la plupart des tubercules. Cependant, chez les derniers apparaissaient sur la peau beaucoup de lésions nécrotiques qui n'existaient pas avant le traitement par le froid (FIG. 1).
Des tubercules exempts de taches de *C. atramentarium* furent exposés en même temps à la même température basse. Sur ces tubercules il n'apparaissait pas de lésions nécrotiques après

le traitement par le froid. (TABLEAUX 1 et 2). Les symptômes morbides que présentaient les tubercules à lésions nécrotiques étaient parfaitement identiques à ceux décrits par WENZL et BRAUN. On en a conclu que la maladie étudiée par les deux auteurs peut être provoquée par l'action de deux facteurs: formation de taches sur les tubercules par *C. atramentarium* et exposition de ces tubercules à des températures en-dessous de 0°C. Si cette hypothèse est exacte, *C. atramentarium* est donc un agent vecteur primaire de cette maladie, ne jouant pas un rôle secondaire comme pensent BRAUN et WENZL.

Le tissu du tubercule subit apparemment l'influence de la présence des taches provoquées par *C. atramentarium* de manière à ce qu'il devienne plus sensible à la gelée dans le voisinage des taches. Il se peut bien que les toxines sécrétées par le champignon vivant dans les taches soit la cause de la sensibilité accrue à la gelée du tissu voisin des taches.

Lors des expériences les tubercules atteints par *C. atramentarium* furent stockés, une partie au sec, une partie dans une ambiance humide, avant de les exposer à des températures basses. Dans l'ambiance humide les taches s'étendirent, ce qui n'était pas le cas des tubercules conservés au sec. Traités à froid, les tubercules stockés humides montraient beaucoup plus de lésions nécrotiques que ceux conservés à l'état sec. Il est vrai que sur les premiers tubercules apparaissaient plus de taches – et c'est pourquoi il serait à prévoir que le nombre des lésions nécrotiques sur ces tubercules était plus grand, le traitement à froid terminé – mais la différence dans l'effet de ce traitement chez les tubercules conservés de façons différentes était trop grande, pour qu'elle puisse être expliquée de cette façon. Elle pourrait être expliquée peut-être si l'on admet que le tissu du tubercule voisin des taches en extension, provoquées par *C. atramentarium*, soit plus fortement influencé par les toxines sécrétées par ce champignon et qu'il soit, par voie de conséquence, plus sensible à la gelée que le tissu voisin des taches qui ne s'étendent pas. Dans ce dernier cas, le mycélium est donc beaucoup moins actif et ne sécrèterait pas ou guère de toxines.

L'auteur à observé que les symptômes morbides correspondant parfaitement à ceux décrits par WENZL et BRAUN – peuvent également apparaître sur des tubercules qui avaient été toujours conservés à des températures supérieures à °C. Il croit donc que ces symptômes peuvent se produire de deux façons.

1e. *C. atramentarium* provoque des taches sur des tubercules de pommes de terre. Lorsque ces tubercules sont exposés à des températures basses, la nécrose péridermique peut apparaître.

2e. Actif, *C. atramentarium* dans certaines conditions pénètre plus profondément dans le tissu du tubercule.

L'auteur estime que, si après un hiver sévère il y a une invasion grave de la nécrose péridermique, elle se produit, en substance, de la première façon. Sur des tubercules qui sont récoltés de bonne heure et stockés au sec l'atteinte par *C. atramentarium* est rare. Ces tubercules sont moins sensibles à la nécrose péridermique provoquée par des températures basses, que les tubercules qui ont été récoltés tard et conservés à l'état humide.

Les expériences seront continuées.

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